Case Study: Process and Outcome Review of a Participative Ergonomics Project in an Asphalt Production Plant

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ABSTRACT

Evidence supporting the benefits of participatory ergonomics is compelling. Ergonomics may improve productivity, mitigate high-risk activity, promote social connectedness, and inspire innovation. However, the practices are not well integrated in many management systems. Program and process evaluation is required to support the sustainability of the practice. This case study describes the selection of a critical control to improve the manual task of sweeping recycled asphalt product (RAP) at a production plant. A multi-criteria decision making model was applied retrospectively to consider the decisions that were made in terms of selecting the control. The case study was reviewed according to an Occupational Perspective of Health, a spectrum of safety through to productivity (or “doing – being – becoming – belonging”). Managers were asked for their input regarding the importance of the ergonomics process, the people involved, and the outcomes achieved. The findings revealed that decision-making models may support a participative design process and ergonomics outcomes may be viewed along a performance continuum and, in this case, address many elements important to good work design. The elements that were perceived to be important to the design process included worker involvement, ergonomist skill set, and task selection.

INTRODUCTION

Construction is a high-risk industry. It ranked as the third highest for fatality incidence in Australia in 2014, representing 15.2% of all worker deaths (28 of 184 deaths) (SWA, 2015\textsuperscript{a}). Over a five-year period, from fiscal year 2007 to 2012, the industry accounted for 11% of serious workers’ compensation claims (SWA, 2013\textsuperscript{a}), inclusive of claims comprising:

- Body stressing (sprain/strain injuries or musculoskeletal disorder): 34%: over half of these were owing to hazardous manual task exposure during human-equipment interface
- Falls, trips, and slips of a person: 25%
- Being hit by moving objects: 16%

There is significant opportunity for the practice of participative ergonomics to make a measurable difference and achieve good work design in industry (Boatman et al, 2015; Dennis & Burgess-Limerick, 2007; Kramer et al, 2009; and Pazell & Burgess-Limerick\textsuperscript{a,b}). Effective program implementation occurs when there is a sense of efficacy among workers to believe that work design may improve productivity and reduce risks more so than personal factors (Village and Ostry, 2010). Programs are best supported in an environment where opinion leaders are encouraged to advocate workplace redesign (Kramer et al, 2009). Further, an organisation must be change-ready as evidenced by budget commitment to implement critical controls or leadership rhetoric (Rogers, 1995; van der Molen et al, 2006; and Village and Ostry, 2010). However, in a study of culture and change readiness, construction workers held the belief that risks, such as musculoskeletal disorder, were inevitable in their work and injury avoidance was a personal responsibility (n = 50 interviewed and 48 in focus groups) (Boatman et al, 2015). Additional barriers to participative ergonomics programs included
perceived productivity pressures, fear of job loss with subsequent low hazard reporting, poor risk
determination practices; lack of awareness of ergonomic interventions, and resources allocated toward
behavioural intervention such as stretching programs rather than work redesign (Boatman et al 2015;
Glimskar and Lundberg, 2013; and Kramer, 2009). Further, while good work design is supported by a number
of tools, resources, legislation and guidance material (e.g. SWA, 2015b), the integration of such artefacts and
the tenets of participative ergonomics is not well established in most total quality management, safety,
workforce strategy, procurement, engineering design, sustainability, health and wellness programming, and
reporting and evaluation systems (Punnett et al, 2009; SWA, 2013b; and Yazdani et al, 2015).

CASE REVIEW

Ergonomics program implementation was trialled within a multi-national construction materials
organisation. The organisation had no known history with participative ergonomics programming and thus
no policies, procedures, reporting systems, or materials devised specifically to integrate ergonomics work
design process in management systems. In the early phase of the program, a number of routine, and
sometimes random, site visits were conducted with observations and conversations held among workers.
This provided for discovery by means of an unstructured interview process. Tasks were identified for further
analysis and brought to the attention of management when there was perceived opportunity for work
redesign to achieve productivity or improved risk management.

Task Identification

The investigator, an ergonomist, attended a recycled asphalt product (RAP) production plant to accompany a
safety advisor when he announced his routine visit to the site. During this visit workers (n = 2) described
their daily tasks. These workers were forthcoming when asked to describe work that had the potential for
redesign. They identified a task perceived to be fatiguing, counteractive to productivity, and with potential
ease for quick control implementation: sweeping the RAP from the plant. Production resulted in layers of
dust and dirt-like particles around the grounds.

Task Description & Methods

Plant operators observed and inspected the production plant grounds throughout their shift. As the RAP dust
collected, an operator used a long-handled standard broom to sweep the fine dust into loads that were
shovelled into wheelbarrows to be dumped into trash bins (up to 3 barrow loads per shift). The majority of
this task was performed at end of shift. The task was estimated to consume up to 4 ½ hours of human
exertion per shift. When shared among the team of 3, this equated to up to 90 minutes of work per person.
Repetition, duration, and fatigue were the most concerning hazards reported by the workers. Neck
discomfort was also reported by one worker. The shifts frequently extended to 13 to 14 hours into late
evening and the work occurred in the outdoor environment around the noise and mechanics of plant activity.
Refer to Figure 1 of the worker sweeping RAP.

Interventions included 3 site visits (initial, control development workshop, and observation of equipment
trial), observations and conversations, data collection with photo imagery and measures, communication
among work teams and line managers, reporting, facilitating risk determination and design strategy,
conducting biomechanical risk calculations, cost benefit analysis with meetings held with finance and
operations, procurement support to determine a supplier for the trial equipment, promoting good work
design with newsletter reporting, retrospective project and process review individually and collectively with
management, and retrospective application of decision-making modelling to review control determination.
methods. The entire project, inclusive of identification, control determination, procurement of new equipment, trial, and reporting took just 8 weeks to resolve (excluding retrospective review).

Risk & Control Determination
A paper-based reporting tool was initially used on-site with worker engagement and consultation to record the hierarchy of tasks, the conditions of work, parties responsible, key stakeholders, hazard conditions, and risk determination using a modified PErforM custom reporting tool. The ManTRA risk calculation was applied, as was the Rapid Upper Limb Assessment (RULA) and Morg-Gaarg Job Strain Index. All risk calculations were positive, indicating the need for intervention. Photo imagery was captured for the report. This data was later used for reporting with an on-line system, ErgoAnalyst™. This on-line system helped provide thermal body map imaging. It calculated and expressed biomechanical risk ratings for acute and cumulative musculoskeletal disorder. It considered, also, the elements of cognitive underload, or fatigue and boredom, associated with hours of sweeping. Refer to Figure 2 and 3 for these images. Productivity costs were also expressed in the report and contrasted with the costs associated with the proposed controls to provide support for expenditure.

Proposed controls were determined with worker consultation during a follow-up visit. The controls that were considered included: a) an industrial manual broom with dual-circular brush heads and a hopper to eliminate the need for shovelling and wheel-barrow use; b) a motor-powered broom also without the need to shovel or use a wheelbarrow; c) installation of more plumbing to provide for more hose outlets that may enable hosing down the grounds; or d) do nothing – continue sweeping with a standard broom. The industrial manual broom with dual circular-brush heads was selected for trial owing to its relatively low cost (<$AUD 500), the ease in procurement process and time to obtain the equipment, the level of worker interest, the potential time savings with higher productivity output, and reduced levels of discomfort and thus risk for musculoskeletal disorder. Refer to Figures 4 – 6.

Two industrial manual push brooms were approved for purchase and trial. They were readily available in the marketplace and the asphalt grounds of the plant were smooth enough to operate in this outdoor environment. The industrial broom had rotating circular brushes that collected the RAP dust into a hopper which eliminated the need to pile the material and prepare for disposal with the use of shovels and wheelbarrows. The hopper could be removed and emptied directly into bins. This new equipment reduced work time to half, a total time of 2hr15min approximately per shift, or 45 minutes per worker if shared among 3. The task was performed intermittently rather than predominantly at the end of the shift.

Through a task-based operator consultation process, the likely time savings identified was 2.5 hours per shift. The financial manager provided an annualised projected cost savings associated with the use of the industrial manual push broom was just over $AUD27K (approximately 2.5 hours’ work saved per shift with at least 5 shifts per week at $45 per hour, 48 weeks per annum).

PROJECT AND PROCESS REVIEW: FINDINGS & DISCUSSION

Effective Control Determination
A review of the decision making associated with effective control implementation was conducted with the application of a basic, weighted, multi-criteria decision making model smart phone application, FYI Decision-
Making by FYI Mobileware, Inc. A number of criteria described influencing factors when determining controls. (Refer to Figure 7).
This weighted decision making model permits the users to describe criteria and rate perceived importance. The model then ranks the criteria in comparative order with weighted percentages. Options are rated by the users against the established criteria and a simple multiplier calculates the final rank order. Figure 7 illustrates the options by rank order determination. The criteria trialled in this model is described in Table 1.

The model for decision-making was applied retrospectively by the investigator, informed by notes and reports taken during the project term and by reflective review with conversations held with management teams. The model supported the decision made: to trial the industrial push broom. The benefit of using decision-making models is to help objectify the decision-making process. It may involve a participative approach and a hallmark feature is the ability to achieve consensus of decisions according to expert opinion (Aminbakhsh, 2013; Mustafa and Al-Bahar, 1991; and Saaty, 1990). In such a way, operators and maintainers as well as managers are considered subject matter experts, akin to a traditional participative ergonomics approach. Multi-criteria decision-making models may permit determination of events that historically lack established measures such as parameters of risk or uncertainty; design philosophy; resource allocation; benchmarking; or quality management systems. Generally, the models are designed to facilitate decisions derived from qualitative experience yet they can be translated in quantitative form with weighted percentages and numeric rank order (Aminbakhsh, 2013 and Saaty, 1990)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest Among Workers</td>
<td>13.9</td>
</tr>
<tr>
<td>Profitability Potential</td>
<td>13.9</td>
</tr>
<tr>
<td>Ease in Control Implementation</td>
<td>12.4</td>
</tr>
<tr>
<td>Impact of Control Intervention</td>
<td>12.4</td>
</tr>
<tr>
<td>Risk Severity Overall</td>
<td>10.9</td>
</tr>
<tr>
<td>Acute Injury Risk Exposure</td>
<td>10.9</td>
</tr>
<tr>
<td>Cost of Critical Control</td>
<td>10.2</td>
</tr>
<tr>
<td>Operations Manager’s Interest</td>
<td>8.0</td>
</tr>
<tr>
<td>Cumulative Injury Risk Exposure</td>
<td>7.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Table 1: Weighted Criteria for Control Options

Figure 7: FYI Decision-Making: Multi-Criteria Decision Making Weighted Model: Smart Phone application
For ergonomics practices and good work design programs to achieve sustainability, resource allocation and sound decision making aligned with organisational strategy is required. With the complexity involved in determining systematic directives for good work design, there is opportunity to apply these types of models on an on-going basis. For example, the models may help determine when, how, and why a task should be escalated for risk determination, design review, and priority action.

Mathematising qualitative aspects of decisions made by subject matter experts can lend persuasion to the argument to advance good work design. This process may translate the needs expressed by safety or health analysts to business, production, or engineering managers.

**Project Outcomes: Occupational Perspective of Health**

The outcomes of this job task redesign was reviewed according to an Occupational Perspective of Health: Doing-Being-Becoming-Belonging (Wilcock, 2006). This is illustrated along a spectrum of project objectives in Figure 8 below. Fatality and severe disability were not considered of paramount concern to the task. Risk for cumulative musculoskeletal disorder of the neck, back, and upper limbs was considered. Operators reported discomfort, fatigue, and poor productivity associated with the task. The introduction of the industrial push broom and the ergonomics process permitted efficient work practice, significant cost savings, integration of operations teams with safety and procurement, and liaison within industry internally through newsletter communications and externally through publication of this task case study in national and international asphalt association gatherings. The operators reported their relief at having advocated for work redesign of a task that they had wanted to address for some time yet that they believed had not received adequate attention during standard hazard reporting mechanisms and forums. The ergonomics process, with the directive to select tasks for redesign, was considered paramount to the change process.

**Process Review: Critical Success Factors**

Critical success factors were reviewed with representatives from management (n = 2) with regard to design of work for health and participatory ergonomics processes (e.g. Vink, 2006). Salient findings are listed below:

1. **Involvement:** worker involvement was rated most important (for communication, hazard identification, and solution development) followed by the presence of an ergonomist (investigator) moderately above operations managers and significantly above safety advisors and suppliers.

2. **Process:** Establishment of a PE project team, hierarchical risk-based task analysis reporting, and engaging positive language to inspire design thinking were determined as the most important aspects. This was followed by iterative design process, routine and random field visits, product trials, and effective reporting tools. Task selection was also considered important: the sweeping task was a daily requirement, important to workers for redesign which had potential to significantly alter efficient work practice with control implementation. The cost of the control was considered low, and the potential impact was significant.

3. **Goals:** Ability to achieve safety, reduced risk for cumulative injury, improved comfort while achieving effective and more profitable work practice was considered important. Equal to this was a fit-for-purpose design solution, realistic outcomes, worker satisfaction, and sustainable work practice.

**CONCLUSION**

Participatory ergonomics programs are fundamental to good work design. This case study has illustrated the process and the benefits to productivity, safety, and continuous quality improvement. Reflective review enabled multi-criteria decision making to be trialed and this practice shows promise as a complement to
participative design. The review also enabled consideration of outcomes that supported the continuum of safety, occupational health, health, wellness, and productivity (e.g. Burgess-Limerick et al, 2011; Cantley et al, 2014; and Lallemand, 2012). The project was evaluated according to an Occupational Perspective of Health (OPH) –“Doing – Being – Becoming – Belonging” - (e.g. Wilcock, 2006). A broader spectrum may include sustainability, recyclability, and ease in construct to deconstruct for future considerations.

Project review, elements of success, and the conditions that led to that success is important for sustainable safe design practice (e.g. Vink, 2006). Factors deemed salient to this project included the involvement of workers and an ergonomist; a positive line of questioning to stimulate design-thinking; and selection of a task where impact could be great with relatively low investment during this early phase of ergonomic program implementation.

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REFERENCES


